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Assessment of social perception of an invasive parakeet using a novel visual survey method

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Abstract

The perceptions of the general public regarding invasive alien species (IAS) are important in the prevention of future invasions and the success of management programmes. Here we use a novel visual method to investigate the perception of a charismatic IAS, the rose-ringed parakeet, across different stakeholders in Seville, Spain. Respondents were asked to select images of 10 bird species they would like to have present in their surroundings, out of 20 available images, including the parakeet and three other non-natives. This makes the survey easy, fast to take and attractive to potential participants, while prior and potentially biasing information of survey goals is minimised. Although more than 95% of the respondents recognised the parakeet, at least up to family level, only 34.8% selected it. Selection rates were even lower for three other IAS and even more so when the status of non-native species was indicated next to the images, suggesting that a social norm against IAS may be established. To validate our novel visual approach, we also assessed perception via a traditional questionnaire and the results of the two survey methods coincided. Finally parakeet selection differed importantly amongst pre-defined sectors of the public and people who had prior experience with the parakeet selected it less frequently (e.g. farmers, park managers). These results highlight the importance of studying different stakeholders to get the full picture when considering IAS management programmes. Our new visual survey method can thus serve as an excellent and user-friendly tool to study people's perceptions regarding charismatic IAS and facilitate well-informed and sensible decision-making.

Keywords

Invasive species, urban ecology, wildlife management, public attitudes, *Psittacula krameri*, rose-ringed parakeet

Introduction

Invasive alien species (IAS) are recognised as being one of the major threats to biodiversity and represent a globally significant and rapidly growing economic cost (Tollington et al. 2017). Effective policy and management responses to the multiple threats posed by IAS are thus essential. However, taking action can be constrained by public objection, especially for charismatic species. Different groups of people can have considerably different social and ethical values, perceptions and knowledge about an ecological issue such as IAS, often resulting in conflict about whether active management such as removal or eradication is appropriate (García-Llorente et al. 2008, Webb and Raffaelli 2008). Public attitudes differ with respect to the type of species in question and the type of management proposed (Fraser 2006). This variation can be related to socio-demographic factors, for example, the types of job people have or the social group they belong to (Vanderhoeven et al. 2011) and people's awareness of impacts (Bremner and Park 2007, Sharp et al. 2011. In addition, social benefits (such as hunting) and other cultural associations can influence attitudes (White et al. 2011). There are also moral arguments surrounding the distinction between native and non-native species (Simberloff 2003) and the potential conservation benefits/detriments of each (Schlaepfer et al. 2011) that can influence people's attitudes. Other factors influencing social perception of invasive species include the taxonomic group the species belong to (Fraser 2006), the type of impact they cause (Fulton et al. 2004) and the severity of their impacts (Reiter et al. 1999).

It is increasingly recognised that the issue of management of invasive non-native species is as much a social issue as it is a scientific one (Reaser 2001, Verbrugge et al. 2013), encompassing political and human factors. Politics and society are part of the management of nature and the support of the general public can be important, since carrying out management may go against the interests of some citizens or pressure groups, which can have negative consequences for the success of the management actions (Bertolino and Genovesi 2003, Crowley et al. 2019). In the case of IAS, the attitude and involvement of the public can be relevant, both for prevention of future invasions and for the success of control or eradication, if needed. However, assessments of the attitudes and perceptions of the general public toward IAS is not often part of the deployed methodology in the management of a biological invasion (Campbell et al. 2015, Dawson et al. 2015). This may, in part, be because invasion biologists focus on compiling evidence on impacts and spread of IAS and on understanding invasion mechanisms. Such information is essential for promoting informed policy, but even persuasive evidence may not be sufficient in influencing values, attitudes and behaviour of people (Clayton and Myers 2009, Courchamp et al. 2017). In addition, conservation or invasion biologists, who are interested in implementing policies to manage IAS, may lack information on the application of suitable and easy methods to collect such social data. They may also be concerned by the outcomes of such analysis, as it can highlight complexities and trade-offs, but these considerations can be essential in prompting effective management and policy.

In this study, we set out to gather information on the perception of the public regarding one charismatic non-native species, the rose-ringed parakeet (*Psittacula krameri*)

in the metropolitan area of Seville (Spain). This parakeet has been introduced from Asia and Africa, establishing approximately 90 populations in 10 European countries (Pârâu et al. 2016). Several studies already demonstrated that rose-ringed parakeet can have both ecological and socio-economic impacts, notably outcompeting local species, damage to agriculture and noise pollution near roost site, but their impacts are often restricted to certain populations and some ecoregions (Turbé et al. 2017). Specifically in Seville, there is strong evidence that parakeets attack, displace and even kill an endangered bat species, the Giant noctule (*Nyctalus lasiopterus*), due to competition over tree cavities for roosting and reproduction (Hernández-Brito et al. 2018). Similar concerns exist with respect to the vulnerable Lesser kestrel (*Falco naumanni*, Hernández-Brito et al. 2014). Evidence from Seville and other Mediterranean countries also demonstrate that parakeets can cause economic and social impacts, as they feed heavily in agricultural areas and roost in large groups in urban localities, producing localised pollution by noise and faeces. On the other hand, the parakeet is a colourful and potentially attractive bird that may add a feeling of wildlife and something exotic to the urban parks where it spends much of its time. Indeed, plans to reduce its population via active management have attracted fierce opposition and, because of this, management has yet to be undertaken. Hence, we hypothesised that the perception of the parakeet could vary considerably amongst different segments of the public, depending on their specific exposure to the parakeet.

Written questionnaires are a common way to study such queries, but the wording and complexity of questions and response bias towards positive normative answers could have large effects on the results (Filion 1981, Paulhus 1991). Additionally, the willingness of people to collaborate in written questionnaires is often low and may be biased (White et al. 2003). To avoid these issues, we developed a novel and visual questionnaire that can cope with those issues presented above and can be used in various conservation contexts. As people often value organisms through subjective criteria such as their aesthetics and usefulness, a more visual approach could be useful to study biodiversity perceptions (Bayne et al. 2012, Shwartz et al. 2013a, Lindemann-Matthies 2016). Hence, our objectives in this study are threefold: first, quantify any differences in the social perception of the parakeet amongst pre-defined parts of the general public; second, to test the usefulness and reliability of a simple novel visual tool in assessing public perceptions on IAS and finally, understand to what extent perceptions change when people are informed or reminded that the parakeet is non-native. This question is important in establishing to what extent efforts to increase awareness to IAS can result in a social norm with respect to non-native species that can influence attitudes and behaviour regarding IAS.

Material and methods

Novel visual tool and questionnaire design

We conducted structured interviews, in which different members of the public who use parks and green spaces in Seville filled-up a close-ended questionnaire, to test the

variation in the perception of the parakeet amongst different stakeholders. We specifically targeted predefined groups which *a priori* we believed might have different perceptions and attitudes towards the parakeet. For the first part of the survey, we developed a plate with 20 images of twenty species of birds present in the parks and gardens of the metropolitan area of Seville, including the rose-ringed parakeet. We then asked each respondent to choose ten of these twenty birds which he or she would like to have present in the environment in which the survey was done. We expect that if the parakeet is perceived more positively, it will be included in this set of 10 species with a greater probability. By not asking anything specific about the parakeet, we avoid the risk of people providing biased responses towards the parakeets or other species.

The selection of species, size, quality and position of the bird images can influence the choices of participants. We therefore carefully selected both colourful species and species with single or dark colours and ensured that our selection represented different functional groups of bird species. To avoid biases with respect to visibility or conspicuousness, we decided to depict species with different sizes to more or less the same size on the plate. We also developed three different plates using three different images for each of the same 20 species: one in which all of them appeared with muted and rather unimpressive colours, one intermediate and another with bright colours. When we did not find three suitable images for some species, we adjusted the contrast and brightness of an image to obtain the desired effect (see Suppl. material 1: Figure SM1). With these three types of images we made plates with duller, intermediate or brighter images. Next, the location of a species in each plate was selected randomly, so that in each plate they appeared in a different position (also in Suppl. material 1: Figure SM1). With this approach, we tried to avoid effects in the selection of the parakeet due to its position in the plate or due to the appearance of the parakeet in any particular image, thereby aiming to obtain more general results.

We included four non-native species, including the rose-ringed parakeet, in each plate and to test whether there is a social norm that acts against non-native species, we made two versions of each of the three different plates presented above, where one version indicated the non-native species by placing the text non-native next to it (see Suppl. material 1: Figure SM2). We expected that people would be less inclined to select a non-native species in their set of 10 preferred species if they think that non-natives have negative effects, whereas they may be more inclined to select them if they think non-natives have positive effects, like contributing novelty.

In order to confirm the validity of this novel visual tool, we asked respondents about their perception of the parakeet using a more traditional question-based survey. In the second part of the survey, we explored attitudes towards the rose-ringed parakeet using a modified version of the companion animal scale (Poresky et al. 1988) (see Suppl. material 1: Figure SM3). This scale was developed for measuring attitudes towards pets, with several items assessing attitude dimensions that would not be expected in human-wildlife relationship, for example loving to not loving, trusting to fearful (Perry-Hill and Prokopy 2014). We therefore reduced the scale's original 18 measurement items down to six, which were suitable for the rose-ringed parakeet and added

five additional adductive pairs: harmless to dangerous, useful to plague, silent to noisy, abundant to rare and muted colour to colourful (following Perry-Hill and Prokopy 2014). Altogether, respondents were asked to indicate the number that best described their opinion for each attitude item, for example, unpleasant to pleasant, clean to dirty, along a 7-point scale, ranging between the positive and negative adjective. To avoid automated answers without paying too much attention, we inverted the order of the 11 adjectives, such that negative adjectives could be either on the left or the right side of the scale that were re-aligned later for data analysis. We expect that if people have a positive opinion about the parakeet, they would score towards the positive adjectives. This was then used to validate the visual approach, by exploring whether people who gave high scores to the parakeets also tend to select the parakeet in the set of ten species in the visual survey. Finally, with this set of characteristics, we can also test which ones contribute most to variation in social perception.

Study design and data collection

The survey was conducted with five pre-defined groups of people between 26 May and 19 June 2014 during two daily periods (8:00–13:00 h and 18:00–20:30 h) in order to test whether social perception of the parakeet depends on prior experience and potential effects of parakeet presence. These groups were: (1) people who live near the roost sites of the parakeets; (2) visitors of parks with parakeets; (3) visitors of parks without parakeets; (4) farmers/agriculturists/gardeners with crops near the city; and (5) people who work in parks with parakeets (gardeners, waiters, street vendors etc.). We carried out between 50–60 surveys per group. In the case of visitors of parks, we selected these people in an unbiased way by inviting every third person encountered to carry out the survey. When the third person was less than 16 years old or someone who was not living in the area, such as foreign tourists or visitors from other cities, we again took the third person encountered. In the case of park workers and farmers, due to the limited numbers of people available in these groups, the surveys were taken with all suitable subjects encountered. To interview visitors of parks without parakeets, we selected parks without parakeets in Seville, as well as parks in towns nearby the Seville metropolitan area in which the parakeets at the time of survey did not breed and can be observed only occasionally. The surveys with visitors of parks with and without parakeets and park workers were each realised in six different parks in order to avoid specific location effects on the results. The surveys with the group of people living close to the roost were realised only in the neighbourhood "Tablada", since this is where the main parakeet roost was located. Finally, we conducted the surveys with the group of farmers/agriculturists in different urban community vegetable gardens and crop fields around the city.

After the visual part of the survey, we asked respondents three questions while pointing to the image of the parakeet to evaluate the level of knowledge and personal experience of rose-ringed parakeet: (1) Do you know this bird? (2) Could you indicate its name? and (3) Have you seen this bird here? We then used the modified version of

the companion animal scale (Poresky et al. 1988) to explore the attitudes towards the rose-ringed parakeet. In the last section of the questionnaire, we collected socio-demographic information, which might also influence social perception and, moreover, which might differ between our pre-defined groups. We recorded information about gender, year of birth, the childhood environment (town, small city or large city), the current environment (same categories) and the last educational degree that has been achieved (up to secondary school graduate, Spanish *Baccalaureate*, intermediate level professional training, superior level professional training, university degree). These data were recorded and stored without the identity or any contact details of the respondent and hence participation was completely anonymous. Participants were informed verbally about the broad aims of the research and chose whether they wanted to answer the questionnaire. Our research activities fall within the scope of categories exempt from IRB approval. Finally, before conducting the survey, we piloted the questionnaire with 35 participants in order to explore the wording and internal validity of the questions used.

Data preparation and analysis

All analyses were done in the R environment (R Core Team 2008). We first confirmed the reliability and consistency of the scores given by the respondents for the 11 items by measuring the attitudes towards the rose-ringed parakeet. Since the responses people gave may be due to one or several underlying dimensions or latent factors that reflect their opinions, we performed a factor analysis of the responses, using the psy package (Falissard 2012). We produced a scree plot of the eigenvalues of the 11 possible factors, with an overlaid distribution of random factors based on 1,000 simulations assuming no correlation structure in the data. We only retained factors with eigenvalues greater than the random expectation. The responses to this questionnaire reflected a single latent factor. Only the first factor had an eigenvalue (5.8) clearly higher than the randomly generated first factor (range: 1.2–1.5); the rest of the factors had eigenvalues equal or lower than randomly generated factors. All its factor loadings were positive and mostly large (Table 1). After verifying internal consistency (i.e. whether respondents answer similar questions in similar ways: Cronbach's alpha = 0.9; values larger than 0.7 are typically taken to indicate internal survey consistency, Rattray and Jones 2007), we summed the scores given by the respondents for each of the 11 items to create a new variable called '*attitude*'. Since all questions were first ordered in the same direction from negative to positive, high attitude score represents positive attitudes towards the parakeet.

To explore which variables determined whether the rose-ringed parakeet was included into the set of 10 preferred bird species, we performed Generalised Linear Models using the binomial error distribution and a logistic link function (MuMIn package, Barton 2017). The main effects (explanatory variables) of interest were the five different groups of people and the availability of information on non-natives. We also tested

Table 1. Exploration of why parakeets are selected in the visual survey. Loadings of each variable on the first and only latent factor of our second, question-based survey (ordered from high to low; 47.9% of the variance captured).

Variable	Loading
Bad/good	0.88
Harmful/harmless	0.83
Worthless/valuable	0.83
Plague/useful	0.81
Unpleasant/pleasant	0.79
Dirty/clean	0.71
Friendly/not friendly	0.67
Noisy/silent	0.56
Abundant/rare	0.54
Ugly/beautiful	0.43
Muted colour/colourful	0.34

for the additional and potentially confounding effects of socio-economic factors, prior knowledge and experience with the species and the type of plate. We therefore fitted a full model using as fixed effects: group (5 categories), information on non-natives (yes or no), gender (male or female), decade of birth (6 categories), childhood environment (3 categories), current environment (3 categories), last educational degree (5 categories), familiar with species (yes or no), experience with species (i.e. whether respondent had previous interaction with the species; yes or no) and type of plate (3 categories). Similarly, we built additional linear models (with Gaussian error structure) to determine the relationships between the above mentioned independent variables and the attitudes toward the rose-ringed parakeet, using 'attitude' as the dependent variable. We also fitted a simple generalised linear model with binomial error structure to explore the relationship between the two different types of attitudes variables measured, the visual and the written questionnaire, with the selection of the parakeet (visual) as the dependent variable and the 'attitude' score as the only independent variable.

We used the R package MuMIn (Barton 2017) to determine the effects and importance of each explanatory variable. Applying this package, we constructed and ran all possible models using subsets of variables, in this case, 512 models, ranked these by Akaike's information criterion corrected for small sample size (AICc) and calculated the Akaike model weights (w_i) (Burnham and Anderson 2002). We then obtained for each variable their model-weighted parameter estimates (Burnham and Anderson 2002). We also obtained the relative importance of each variable by summing the Akaike weights (w_i) of the models in which each variable was included. As a rule of thumb, an importance >0.5 corresponds to roughly a p-value <0.05 (Shwartz et al. 2013b). We think this model-averaged and information theoretic approach gives a much more integrative overview of the variable's effects than the results of a single model, especially for models including many explanatory variables such as ours.

Results

Altogether, 276 people participated in our survey and were distributed across the experience groups as follows: 54 workers in parks, 60 visitors in parks with and 60 in parks without parakeets, 50 participants living near the roost and 52 farmers.

People generally recognise the parakeet but personal experience varies

Across the survey, 80.1% of the respondents indicated that they knew the rose-ringed parakeet. The vast majority of workers in parks (90.7%), people who live near the roost (88.0%) and farmers (84.6%) said they knew the parakeet. Although the percentages of all groups were high, always exceeding 50%, only 78% of the visitors of parks without parakeets and 62% of the visitors of parks with parakeets, indicated that they knew the species. When asked for the name of the bird, none of the respondents gave an answer that indicated they misidentified it as a parakeet: all people mentioned names that are associated with the family Psittacidae (Parrots). Almost half (52.9%) said parrot, 18.5% said parakeet -without saying the complete name- and 11.2% said names of other parrots such as macaw or lovebird. Only one person named the species correctly and a very small fraction (4.7%) chose the option 'Do not know/ Do not answer'. A total of 56.9% of the respondents replied that they had seen the species before. Workers and people living close to the roost obtained higher percentages (87.0% and 80.0%, respectively); visitors of parks without parakeets obtained the lowest percentage (17%), as expected.

Preference for parakeets is generally low and differs between groups of people

In the visual survey, 34.8% (out of N=276) of participants chose the parakeet as one of the 10 preferred birds. Since random choice would yield on average 50%, this lower percentage indicates an overall aversion towards the parakeet. There were notable differences amongst the groups of people in this respect. The group that chose the parakeet most was the visitors of parks with parakeets (53.3%, out of N=60); this was the only group in which the parakeet was selected by more than half of the respondents. However, after controlling for social and demographic differences between groups, no group chose the parakeet more than half of the times (Figure 1). The groups which selected the parakeets least were farmers (17.3%, out of N=52) and neighbours living close to the roost (22.0%, out of N=50). The group of workers in parks selected it 37.0% of the times (out of N=54). These group differences are statistically important, even when controlling for potentially confounding social and demographic variables (Table 2). With respect to these, gender was important: men selected parakeets less frequently than women. Finally, people who had seen the parakeet before had a reduced probability of choosing the parakeet.

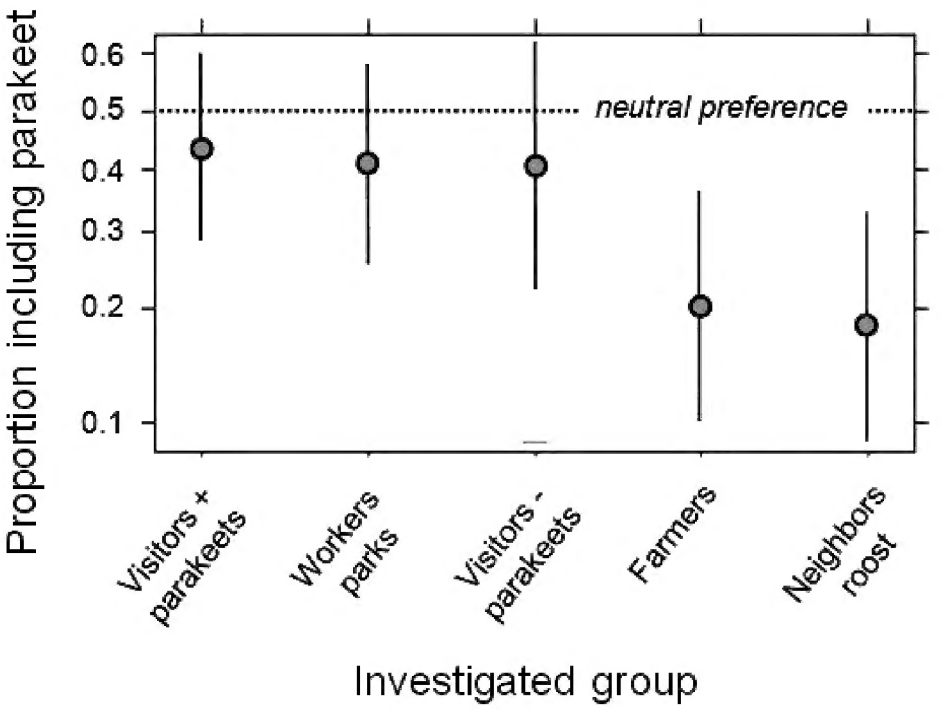

Figure 1. Differences amongst people in their response towards parakeets. Proportion of individuals per pre-defined survey group that included the parakeet into their list of 10 preferred birds, ordered from high to low (and corrected for all variables included in the statistical analysis, see Table 1). Since people could choose 10 out of 20 birds on offer, a neutral preference would result in a 50% probability of inclusion (dotted line).

A mild but generalised disliking of non-natives

Providing information that the parakeet was non-native did not importantly change its probability for selection, although it did decline (Table 2). In addition, for the other three non-native species, we found similar and often much larger declines in their probability to be chosen when it was indicated that they were non-native: selection rates of the red avadavat (*Amandava amandava*), rock dove (*Columba livia*) and common waxbill (*Estrilda astrild*) were reduced by 23.8%, 6.82 % and 13.0%, respectively. In accordance, in separate models for each of these species, information on being non-native was always an important contributor (importance estimates for each species: 1.00 ($\approx p<0.001$), 0.59 ($\approx p<0.05$) and 0.81 ($\approx p<0.05$), respectively).

The two different survey methods give very similar and meaningful results

There was no effect of which plate people used in the visual survey, suggesting the results reflect true preference. In accordance with this, the GLM results to explain the results of the visual survey were very similar to the results for the variable 'attitude', both qualitatively, ranking and sign and quantitatively, relative importance (Table 2). In addition, a model explaining the results of the visual survey with the attitude values had an AIC value that was 167.7 points lower than a model that only included the intercept, i.e. the attitude values predicted the probability to choose the parakeet.

Table 2. Pattern of covariance amongst the 11 attitude items. Effects of different characteristics of respondents on their probability to include the rose-ringed parakeet in the set of 10 preferred birds in the first, visual survey ("*Parakeet chosen*"), ranked by their relative importance in the models. Estimates (and their standard errors) given are the untransformed and model-weighted coefficients from all possible binomial regression models; relative importance of each variable is the sum of the Akaike weights (w_i) of the models in which each variable was included. As a rule of thumb, an importance >0.5 corresponded to roughly a p-value <0.05 (*) and importance >0.95 to p <0.01 (**) (Shwartz et al. 2013b). In the two rightmost columns the same is provided, but then for the summed attitude score towards the parakeet from the second, question-based survey ("*Attitude*"). Note the similarity in ranking, relative importance and sign of the estimates between the two different survey methodologies. (Reference levels for the variables were as follows: gender=female, experience with parakeet=no, group=visitors to parks without parakeets, current environment=large city, information available on non-native=no, familiar with=no, childhood environment=large city, plate used=bright, last diploma=Spanish baccalaureate, year of birth=1930-1949).

Variable	Parakeet chosen		Attitude	
	Estimate (SE)	Importance	Estimate (SE)	Importance
Intercept	0.80 (0.65)		60.5 (3.06)	
Gender (male)	-0.81 (0.34)	0.96 **	-5.72 (1.44)	1.00**
Experience with parakeet? (yes)	-0.90 (0.41)	0.94*	-9.35 (1.81)	1.00**
Group (farmers)	-0.63 (0.62)	0.85*	-4.37 (2.47)	1.00**
" (roost)	-0.68 (0.73)		-8.39 (2.83)	
" (visitors parks with parakeets)	0.29 (0.61)		0.75 (2.62)	
" (workers)	0.20 (0.63)		-3.66 (2.77)	
Current environment (small city)	-0.95 (1.03)	0.58*	-1.47 (3.17)	0.29
" (town)	-0.43 (0.50)		-0.77 (1.62)	
Information available on non-native (yes)	-0.06 (0.17)	0.30	-0.02 (0.65)	0.25
Familiarity with parakeet? (yes)	-0.07 (0.26)	0.30	-1.28 (1.93)	0.47
Childhood environment (small city)	-0.15 (0.41)	0.25	-0.70 (1.81)	0.23
" (town)	-0.11 (0.25)		0.08 (0.77)	
Plate used (dark)	-0.03 (0.14)	0.13	0.09 (0.61)	0.13
" (intermediate)	0.004 (0.12)		0.14 (0.67)	
Last diploma (university degree)	-0.04 (0.18)	0.07	-0.24 (1.00)	0.08
" (professional training superior level)	-0.001 (0.13)		-0.17 (0.91)	
" (professional training interm. level)	0.0005 (0.09)		-0.18 (0.77)	
" (primary/secondary school graduate)	-0.04 (0.19)		-0.26 (1.05)	
Year of birth (1950–59)	0.0004 (0.07)	0.01	0.20 (1.47)	0.17
" (1960–69)	-0.003 (0.07)		-0.41 (1.62)	
" (1970–79)	-0.002 (0.07)		-0.004 (1.30)	
" (1980–89)	0.0006 (0.07)		0.32 (1.54)	
" (1990–99)	-0.004 (0.09)		0.64 (2.23)	

Discussion

Recently, Courchamp et al. (2017) summarised the key problems and possible solutions in the field of invasion biology. They argued that "one major impediment to the support of studies and action in biological invasions is the huge sympathy capital for many IAS" and especially the ones that are beautiful and cute. Results from a few reports and other anecdotal evidence support this claim for alien parakeets. For instance, in Europe, three surveys conducted in France and Germany have identified that the majority of respondents find the rose-ringed parakeet attractive and like to see them in gardens and parks (Scalliet 1999, Wegener 2004, Wolff and Touratier 2010). These

attitudes and perceptions may cause public objections towards any attempt to manage problems posed by charismatic IAS (as is currently the case for the parakeet in Seville, where the political decision to eliminate the parakeet was subsequently halted by animal protection groups). In the search of a solution, Courchamp et al. (2017) suggest to change the science communication paradigm in invasion biology from the deficit model, which postulates that knowledge transfer to the public will convince the latter about the importance and reliability of the issue, to the dialogue model, which calls for open interchange with the public. Our study embraces and facilitates this approach by developing a simple and novel visual tool for surveying people's attitudes towards charismatic alien species. Using this novel methodology, we find that the parakeet is not overly preferred compared to other local species, but that attitudes may vary strongly between different stakeholders. Importantly, preference appears related to the type and degree of exposure to parakeets.

Social perception of an invasive parakeet: variation amongst people

A few recent studies have highlighted a lack of ecological knowledge in identifying the names of common species in urban areas (reviewed by Pett et al. 2016). Our results demonstrate that this was not the case for the rose-ringed parakeet, which the vast majority of participants were able to identify correctly. Nonetheless, the majority of participants (65.2%) did not choose the parakeet. This suggests that the species is less popular than the average bird species depicted on the plates we used (see Suppl. material 1: Figure SM1) and that there is general aversion towards the parakeet. Similar results were obtained in Paris (France), where the rose-ringed parakeet was only placed in 8% of the gardens people designed, ranking 29th out of 32 species proposed (Shwartz et al. 2013a).

The popularity of the parakeet differed systematically amongst participants. In both the visual survey and the question-based survey, men were less likely to include the parakeet. Other studies have identified some mixed results regarding the effect of gender. For instance, men provided more accurate estimations of the richness of birds, flowers and insects in urban gardens (Shwartz et al. 2014), but included fewer animal and flower species in ideal gardens they designed (Shwartz et al. 2013a). While we do not have a clear explanation for this, it is known that there are fundamental differences in the ethical perceptions, values and attitudes of men and women on issues such as wildlife control and ecological problems (Lauber et al. 2001, Dougherty et al. 2003, Bremner and Park 2007). This might have played a role, together with other differences in perceptions and preferences between men and women (e.g. women place greater importance on aesthetics, see Lindemann-Matthies 2016). Therefore, in any kind of survey, gender of the respondent is a factor that needs to be taken into account, both in design or analysis and interpretation.

Another effect in both surveys was that people, who had seen the parakeet before, had a more negative opinion. These results somewhat contradict recent studies that demonstrate how interaction with charismatic species, notably mammals and even dangerous ones, can yield positive attitudes towards their conservation (Bjurlin and Cypher 2005, Bruskotter

et al. 2017, Shwartz et al. 2013a). A possible explanation for our result may be that prior information about the parakeet and its impacts (e.g. coverage in the media) increase both a negative attitude towards the parakeet and the probability that it is detected/recognised. This may be especially true for stakeholders potentially exposed to negative impacts by the parakeets, like farmers, people who live close to the roost and park managers, which were not covered by the studies mentioned above which focused on the general public.

In fact, one of the aims of our survey was to test if there are differences in the social perception of the parakeet amongst pre-defined parts of the general public. Indeed we found, in both types of surveys, that the perception of the parakeet was different amongst our groups, even after statistically controlling for socio-demographic variables. This may be due to the type of interactions that these groups have with the parakeet, as such a result has also been found in other studies that included groups with diverse types of interaction with the subject of study (García-Llorente et al. 2008). Visitors to parks with and without parakeets had a more favourable attitude towards the parakeet. These people only go to the parks infrequently and do not necessarily have negative or any interaction with the parakeets. Some visitors may like to have parakeets in the city and had an informed favourable opinion about them. In contrast, people involved in agriculture and those living close to the roost had a more negative attitude towards the parakeet. These people probably have had more interactions with the parakeets and may have been exposed to or know about negative impacts, such as damage to agricultural crops and pollution with noise and faeces (Bremner and Park 2007, Canavelli et al. 2013). Overall then, the perception of the parakeet appears to depend on the level of interaction with and knowledge about the species; people who suffer the risk of the noise, dirt or damage from the parakeets have a worse opinion about the parakeets and in majority do not want parakeets in their city or town when given a choice. As the species becomes more common and is affecting more people working in agriculture and living close to one of the roosts, it is likely that the average attitude will only become more negative in the future. This could provide a major argument in the open discussion with the public, when considering early action against establishing non-natives.

Such information about heterogeneity in public opinion is crucial when employing the dialogue model to management (Crowley et al. 2016, Courchamp et al. 2017). First, it is important that all relevant stakeholders are engaged in the discussion. In addition, however, it is important that different stakeholders sections are informed about each other´s opinion and the reasons behind them. This may reduce "human-human" conflict which results from conflicting values and interests of different sections of the society (White and Ward 2010) and thereby promote consensus across sections, i.e. a beneficial interaction between the dialogue and the deficit model.

The results of the Factor Analysis indicated that there was only a single underlying latent factor representing the responses to the question-based survey. However, the variables reflecting the parakeet's aesthetic characteristics were not very correlated with this latent factor as they had the lowest factor loadings. Hence, the general opinion is dominated by characteristics that we could call more pragmatic characteristics, for example bad/good, harmful/harmless, worthless/valuable, plague/useful etc. Indeed,

when talking to respondents after the survey was concluded, they often commented on the use or role of parakeets in nature and in urban and rural communities, instead of on their aesthetic characteristics.

Suitability of the visual survey approach to assess social perception

Several studies have highlighted the usefulness of adopting a visual approach when studying people's preference for nature or biodiversity (e.g. Bayne et al. 2012, Shwartz et al. 2013a, Lišková and Frynta 2013), but this has only rarely been done for invasive species (Lindemann-Matthies 2016). Here we used a rather novel approach to investigate people´s perception of a focal non-native species, by presenting an image of it mixed with those of other species and then asking people to select a fixed-number subset of species they prefer. This design has several advantages. First, we did not ask people to somehow qualify the images according to some of our pre-established criteria, but to just use their own. Second, it remains unknown that one (or a few) of the species is a focal species of the study, avoiding biased answers. And third, a generalised positive (or negative) response bias towards all species is impossible, since only a limited set of species can be positively selected and the rest has to be selected against.

Due to its ease, visual attraction and 'game-like' nature, in our experience respondents were very keen to participate in the survey. Similar advantages were also recorded in a study that used a visual approach and gamification, a user-friendly 3-dimensional computer programme that allows people to design their ideal garden and to explore the biodiversity people want in urban green spaces (e.g. Shwartz et al. 2013a). We feel that such user-friendly visual approaches can increase the probability of involving various social groups in the research, for example, elderly people or children, those with a lower formal education or people without a special interest in nature, as is often not the case in other studies (White et al. 2003, Lindemann-Matthies 2016). This approach can thus be useful for reducing the self-selection bias for people with positive attitudes to nature and response bias (i.e. respondents' tendency to provide answers that are socially acceptable; Paulhus 1991), as no information on the special interest for the focal species was given in the visual part of the survey.

Our results confirmed that people recognised that the focal species depicted in the plate was a parrot of some sort, indicating that the information we obtained is relevant for the species of interest. Next, the usage of a specific image or its location on a plate could influence the probability that the image is selected, but we did not find any effect of using different plates which varied in quality and location of the images. Nonetheless, in visual surveys a random subset of images and locations could be used to generate variation amongst plates which are then randomly presented to a respondent, in order to avoid any image and location biases. In view of the above, we conclude that, in our surveys, the decision to include the parakeet in the subset of preferred species was made consciously. In addition, the visual survey and the classical question-based survey yielded very similar results and one could predict the results of the other. Hence, the similarity in

results between the two types of survey, novel versus classical, confirms that the respondents took part in the visual survey while taking their opinions and feelings specifically about the parakeet into account, even when they did not know this was our focal species. This implies that the novel visual survey is a valid method to assay social perception.

Is there a generalised disliking of non-native species?

There is a controversial aspect as to whether the origin of certain species influences attitudes in conservation (Van der Wal et al. 2015). In our results, we saw a mild and statistically non-important reduction in the probability to include the parakeet in the preferred set when presented as a non-native. In the case of the other three non-native species included in the survey (*Estrilda astrild*, *Amandava amandava* and *Columba livia),* there was also a consistent, sometimes large and always statistically important reduction when indicating they were non-native. Similar patterns were also found in Paris (France), when participants were asked to design their ideal gardens: most non-local species were excluded from the gardens (Shwartz et al. 2013a). Altogether these results may indicate that, overall, people do care whether species are native or non-native and take this information into account when selecting species. If so, it means that all sorts of information and campaigns on the potential negative effects of non-native species have managed to influence people´s opinions about non-natives and have formed a social norm against some IAS. In that case, it also suggests that support for active management against non-native species, or prevention of future introductions, can be increased by information campaigns (Courchamp et al. 2017, Novoa et al. 2017).

Conclusion

The novel visual approach we present here suggests that the obtained information is reliable. Importantly, the visual survey is easy to take, has a very high participation rate and the data are fast and easy to analyse. Moreover, it gives an indication of perception and attitude relative to other species. Such a ranked perception could facilitate decision-making, since management is often about setting priorities in the face of limited resources. We therefore think our visual approach might be a good tool for conservation biologists who need to collect information on social perception on any kind of topic (as long as it can be captured in images), including biological invasions. In our case, it allowed us to establish that different sections of the public have different perceptions about the invasive rose-ringed parakeet, that perceptions are worse in those sections that are exposed more to negative impacts of parakeets and that there appears to be a social norm against invasive species. These are insights that should be helpful when deciding over actions against invasive species (Crowley et al. 2017). For example, for the parakeet in Seville, it might be helpful for managers to realise that public experience with the species decreases its desirability, suggesting a generally

worse perception as the species continues to increase. In addition, it might be helpful to communicate that, while some sections of the public are rather indifferent, others are decidedly negative in view of concrete interactions (people living close to roosting sites) – recognition of this may promote support for actions by the entire public. In general, information on social perception can be essential for effective policy, management and communication with the public.

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Supplementary material 1

Figures SM1–SM3

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